Nuclear Energy Plant Optimization (NEPO) Program

2001 Annual Report
February 2002

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1.0 Purpose

This Report describes the accomplishments and status of the Nuclear Energy Plant Optimization (NEPO) Program for Fiscal Years (FY) 2000 and 2001. NEPO was a new program initiated in FY 2000. This first annual report provides a brief synopsis of the program background, goals, and project selection process; a summary of research and development projects; and highlights of key results achieved to date. Finally, future directions of the program are discussed.

2.0 Program Background

In November 1997 the President's Committee of Advisors on Science and Technology (PCAST) issued a report recommending that the Department of Energy (DOE) work with its laboratories and the utility industry to develop a program to address the problems that may prevent continued operation of current nuclear plants. The NEPO program, initiated in FY 2000, supports research and development focused on improving the operations and reliability of currently operating nuclear power plants while maintaining a high level of safety. The program relies on industry to fund at least half of its research agenda and is designed to encourage the electric utility industry to conduct longer-term or higher risk research. The research conducted under the NEPO program aims to make U.S. nuclear power plants more efficient and reliable than they would have been without the Department's involvement. The industry cost-share comes through the Electric Power Research Institute (EPRI). Congress appropriated $5 million annually in DOE funds for the NEPO program in FY 2000 and FY 2001 and EPRI provided nearly $7 million in FY 2000 and over $6 million in FY 2001.

Research conducted in this program is based on the *Joint DOE-EPRI Strategic R&D Plan to Optimize U. S. Nuclear Power Plants*, hereafter referred to as the *Joint Strategic Plan*. The program is guided by the Nuclear Energy Research Advisory Committee (NERAC) Subcommittee on Operating Nuclear Plant Research, Coordination and Planning. Additionally, a Government-industry coordinating committee has been established. The Coordinating Committee for Joint DOE-EPRI Strategic R&D Plan to Optimize U.S. Nuclear Power Plants, hereafter referred to as the Coordinating Committee, reviews the proposed research areas and makes recommendations on project prioritization to DOE and EPRI. The Coordinating Committee, composed largely of utility executives, also includes representatives from the Nuclear Regulatory Commission (NRC), the Institute of Nuclear Power Operations (INPO), the Nuclear Energy Institute (NEI), the national laboratories, and the university community.

3.0 Goals and Objectives

The goal of the NEPO program is to ensure that current nuclear plants can continue to deliver adequate and affordable energy supplies up to and beyond their initial license period by resolving

critical issues related to long-term plant aging, and by developing advanced technologies to improve plant reliability, availability, and productivity. The research and development (R&D) conducted under the NEPO program is categorized into two program elements, Aging Management and Generation Optimization.

Aging Management R&D is conducted to understand, characterize, and manage or mitigate effects of plant aging on key plant components, such as reactor pressure vessels and vessel internals, steam generators, electric cables, primary system piping, and safety-related concrete structures. Generation Optimization R&D includes development and demonstration of technologies to optimize the power output from existing nuclear power plants such as technologies needed to replace obsolete analog equipment, advance nuclear fuel performance, quantify risks, and address human performance issues.

The technical objectives of the NEPO program include:

- Managing long-term effects of component aging: Component and structural material degradation occurs in nuclear plants as a result of long-term operation and exposure of materials to harsh environmental conditions. R&D conducted under NEPO will provide a better understanding of degradation mechanisms and how they occur, enabling development of cost-effective aging management strategies to prevent, detect or repair the effects of degradation.

- Improving efficiency and productivity of existing nuclear power stations: This objective focuses on improving the long-term economic performance of current plants through development of technologies that will improve equipment reliability, lower operating costs, and increase power output while maintaining high levels of safety. Current nuclear plants were designed and are operating with technology developed over twenty-five years ago. As these nuclear plants age, components and parts degrade or become obsolete, introducing inefficiencies, added costs, and reduced reliability. There have been significant technology advancements over the past twenty-five years that are applicable to power generation, particularly in computers, communications, materials, sensors and digital electronics, and artificial intelligence. R&D conducted under the NEPO program will develop the technical basis required for regulatory approval to use these more accurate, reliable and cost-effective technologies at existing nuclear power plants. The program will also produce new technology applications that will make nuclear plant operation and maintenance processes more economical and increase overall plant output.

4.0 Program Implementation

In 2000 and 2001, a public workshop was held to elicit input from the stakeholders on areas of research that should be considered for NEPO funding (see Figure 1). The workshop facilitated discussions on the key technical issues facing current operating plants, research needed to resolve these issues, and R&D currently being performed domestically and internationally. These discussions helped to define remaining research needs and resources required for resolving these issues. Projects were proposed by stakeholders including utilities, vendors, national laboratories,

universities, and NRC. Research topics are classified as either Plant Aging or Generation Optimization. From the workshop, a list of potential research areas was defined for further consideration by DOE and EPRI.

The Department then reviewed the research proposed at the workshop to ensure that the projects considered under the NEPO program are appropriate for funding by the Federal Government. The Coordinating Committee reviewed proposed projects identified through the annual workshop and made recommendations on project prioritization to DOE and EPRI. Prioritization is made without regard to who will perform the work.

Final projects were selected for joint DOE and EPRI funding based on the recommendations provided by the Coordinating Committee, recommendations from NERAC, as well as, DOE and EPRI management review.

Following DOE and EPRI selection of projects to be funded, appropriate procurement categories were determined. R&D projects could either be performed at national laboratories or by commercial contractors. National laboratories were awarded those projects for which the national laboratories have unique capabilities not available in the commercial sector. Projects performed by national laboratories were funded directly by DOE. For projects performed by private sector contractors, DOE funding was transferred to EPRI via a cooperative agreement and projects were awarded through EPRI contracting mechanisms. National laboratories and commercial vendors never competed for the same NEPO projects. Strong priority was placed on open competition of tasks, both at national laboratories and at commercial contractors. Each selected contractor performed the R&D with oversight from both EPRI and DOE. The process for identification and selection of NEPO projects is shown in Figure 1.

5.0 NEPO Projects

With FY 2000 funds, 14 separate projects were initiated for a total DOE funding of $4,765,000. In addition to this DOE funding, the nuclear industry through EPRI contributed $6,983,000 to the NEPO research efforts. The projects included R&D in both Aging Management and Generation Optimization. With FY 2001 funds, additional research activities were continued on 10 of the projects initiated with FY 2000 funds, and 8 new projects were initiated for a total DOE funding for 2001 of $4,742,350. The nuclear industry contribution through EPRI for FY 2001 was $6,357,000.

The 14 FY 2000 projects provide for R&D on steam generator non-destructive evaluation, plant chemistry, aging of electrical cables, steel aging and fatigue, and digital instrumentation and control systems. The eight new projects initiated in FY 2001 provide for R&D on insulation systems qualified for harsh environments for use in replacing aging motors, risk based technologies including probabilistic risk assessment (PRA) benchmarking for low power and plant shutdown conditions, and on-line monitoring and diagnostics technologies. NEPO projects conducted to date have involved a wide range of topics and have engaged more than 20 organizations in the research effort, including national laboratories, nuclear plant

owner/operators, nuclear equipment suppliers, and industry consultants. The project titles, investigators, and funding for each project are listed in Tables 1 through 4. Aging Management projects are listed in Tables 1 and 3 and Generation Optimization projects are listed in Tables 2 and 5. A short description and summary of the status of each project is provided in Attachments A and B.

5.1 Minority Educational Institution Participation

In FY 2001, the NEPO program emphasized inclusion of minority educational institutions. Awards were made to minority educational institutions to conduct NEPO related R&D activities, and students and faculty from minority institutions were selected for summer internships.

In FY 2001, the DOE Minority-Majority Partnership Program in Nuclear Engineering was expanded to offer additional funding for research work under the NEPO program. The participating minority universities – South Carolina State University, North Carolina Agricultural & Technical State University, and New Mexico State University – were invited to submit grant applications to perform research that supports the goals of the NEPO program and matches the interests and capabilities of minority universities.

Grant applications received from the participating minority universities were independently reviewed by subject area experts from DOE, national laboratories, and EPRI. Based on the results of the peer review, DOE and EPRI made two awards. DOE awarded $102, 945 to New Mexico State University to conduct research on automated diagnosis and classification of steam generator tube defects. An award of $48,639 was made by EPRI to the North Carolina Agricultural & Technical State University to develop a simulation model for PWR flow system thermal stress fatigue.

In addition to the above awards, summer internships were awarded to one faculty member from Tennessee State University and three students from University of New Mexico to work on NEPO projects being conducted at national laboratories. EPRI also awarded summer internships to two students from Prairie View A&M University.

NEPO Project Identification and Selection Process

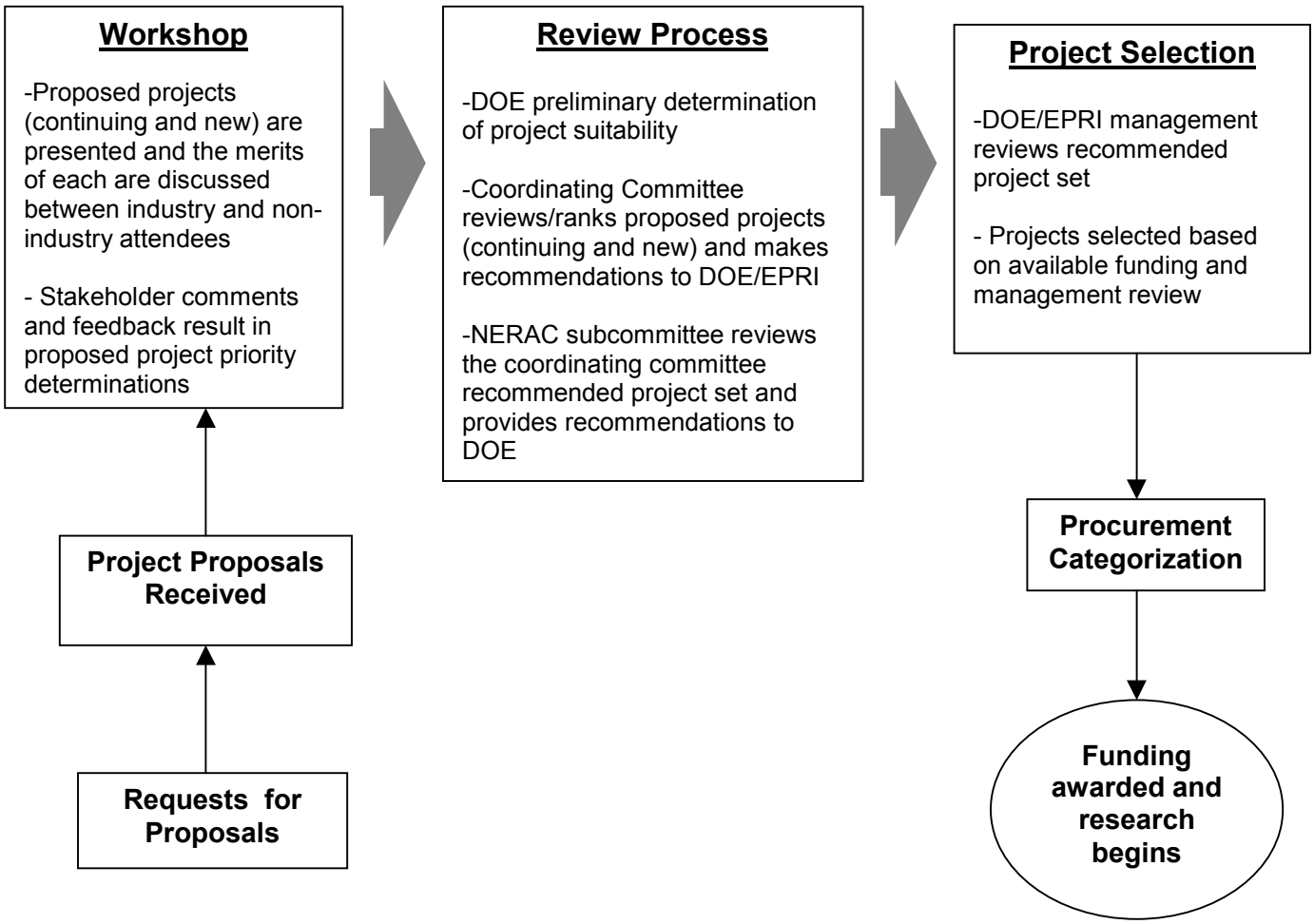

Figure 1

Table 1. Summary of FY 2000 NEPO Aging Management Projects

Project ID	Project Title	Investigators (Recipients of DOE Funding)	FY 2000 DOE Funding	FY 2000 EPRI Funding
3-1	Steam Generator Non-Destructive Examination Test Mockup Facility and Tube Degradation Database	ANL	$400,000	$100,000
3-2	Advanced Eddy-Current Inspection System for Detection and Characterization of Defects in Steam Generator Tubes	ANL	$252,000	$250,000
3-3	Overcoming Solubility Limitations to Zinc Addition in PWRs	ORNL	$170,000	$70,000
3-7	Develop Empirical Data to Characterize Aging Degradation of Polymers Used in Electrical Cable	SNL, Nutherm International, Inc., Wyle Laboratories	$578,390	$260,000
3-8	Develop Condition Monitoring Techniques for Electrical Cable	Nutherm International, Inc., SNL, Kinectrics, Scientech.	$605,420	$110,000
3-13	Mechanical Behavior of Irradiated Structural Stainless Steels	ANL/LLNL	$400,000	$2,935,000
3-24	Fatigue Management	Framatome Technologies, Inc, Continuum Dynamics Inc., General Electric, Wais & Associates, PNNL, Structural Integrity Associates	$599,380	$1,820,000
3-27	Assessment of Aging Effects on Components and Structures from Nuclear Power Plants	ORNL, PNNL	$349,850	$270,000
3-30	Irradiation Induced Swelling and Stress Relaxation of PWR Reactor Core Internal Components	SRI International	$449,971	$193,000

Table 2. Summary of FY 2000 NEPO Generation Optimization Projects

Project ID	Project Title	Investigators (Recipients of DOE Funding)	FY 2000 DOE Funding	FY 2000 EPRI Funding
5-10	Qualification of a Smart Transmitter for Nuclear Safety Applications	MPR Associates	$199,950	$200,000
5-12	Revision of Guideline on Licensing Digital Upgrades Based on Revised 10 CFR 50.59 Rule	MPR Associates	$99,960	$125,000
5-17	Cost-Benefit Study for Optimum Fuel Burnup and Cycle Length	Westinghouse, Exelon	$210,119	$100,000
5-19	Impact of Nickel Oxide Solubility on Axial Offset Anomaly in PWRs	ORNL	$200,000	$200,000
5-21	Human Performance Indicators and Corrective Action Plans	John Wreathall & Company, Inc., Galaxy Scientific	$249,960	$350,000
GRAND TOTAL (Aging and Optimization projects)			**$4,765,000**	**$6,983,000**

Table 3. Summary of FY 2001 NEPO Aging Management Projects

Project ID	Project Title	Investigators (Recipients of DOE Funding)	FY 2001 DOE Funding	FY 2001 EPRI Funding
3-1	Steam Generator Non-Destructive Examination Test Mockup Facility	ANL	$350,000	$100,000
3-2	Advanced Eddy-Current Inspection System for Detection and Characterization of Defects in Steam Generator Tubes	ANL	$300,000	$250,000
3-7	Develop Empirical Data to Characterize Aging Degradation of Polymers Used in Electrical Cable	SNL	$327,000	$70,000
3-8	Develop Condition Monitoring Techniques for Electrical Cable	SNL, Scientech, AMEC Earth & Environmental, Kinectrics,	$591,019	$800,000
3-13	Mechanical Behavior of Irradiated Structural Stainless Steels	ANL, LLNL	$407,000	$1,990,000
3-24	Fatigue Management	PNNL, Continuum Dynamics Inc., General Electric, Wais & Associates, Structural Integrity Associates	$560,638	$1,543,000
3-27	Assessment of Aging Effects on Components and Structures from Nuclear Power Plants	PNNL	$50,000	$30,000
3-29	Motor Rewind Insulation Systems Development and Qualification for Harsh Environments	Nuclear Logistics	$261,696	$119,000
3-30	Irradiation Induced Swelling and Stress Relaxation of PWR Reactor Core Internal Components	SRI International	$603,713	$341,000

Table 4. Summary of FY 2001 NEPO Generation Optimization Projects

Project ID	Project Title	Investigators (Recipients of DOE Funding)	FY 2001 DOE Funding	FY 2001 EPRI Funding
5-12	Revision of Guideline on Licensing Digital Upgrades Based on Revised 10 CFR 50.59 Rule	MPR Associates	$28,750	$25,000
5-17	Cost-Benefit Study for Optimum Fuel Burnup and Cycle Length	Westinghouse, Exelon	$205,334	$100,000
5-106	Low Power and Shutdown Probabilistic Risk Assessment (PRA) Benchmarking	Scientech	$283,750	$150,000
5-107	Develop Methods to Incorporate Organizations Factors into Risk	Data Systems and Solutions, Electricite de France	$78,750	$75,000
5-108	Organizational Factors Leadership Process Development	John Wreathall & Company	$128,750	$125,000
5-110	Human Factors Guidance for Digital I&C Systems and Hybrid Control Rooms	BNL	$200,000	$285,000
5-113	On-line Monitoring of Non-redundant Sensors for Signal Validation and Calibration Reduction	ANL	$108,600	$84,000
5-115	Electromagnetic Interference (EMI) Testing Requirement for Nuclear Power Plants	Wyle Laboratories	$105,350	$125,000
5-117	R&D Needs to Address Potential Nuclear Plant Vulnerabilities arising from Transmission Grid Voltage Inadequacies	ORNL, SAIC, Data Systems and Solutions	$152,000	$145,000
GRAND TOTAL (Aging and Optimization projects)			**$4,742,350**	**$6,357,000**

6.0 Program Activities, Accomplishments, and Highlights

The NEPO program was initiated in fiscal year 2000. In this first year significant effort was directed towards establishing mechanisms for the identification of candidate projects, selection of projects for funding, management of the work, and reporting of the results. A memorandum of understanding between DOE and EPRI was established and a Cooperative Agreement was awarded to EPRI to support the selection process described in section 4.0, and to facilitate private sector awards and joint management of R&D. The Coordinating Committee charter was developed and the members selected.

The entire *Joint Strategic Plan* was rewritten during FY 2000 and the revised plan was issued on October 17, 2000. The updates to Volume 1 de-emphasized license renewal, as plants were successfully navigating the renewal process, and sharpened the focus on Plant Aging and Generation Optimization. Volume 2 was updated with the most current listing of critical research and development needs.

In FY 2001, emphasis was placed on including minority educational institutions in the program as described in Section 5.1.

7.0 Future Direction

The processes established for the NEPO program to identify, prioritize, select, and award R&D projects worked effectively to direct DOE and industry cost-share funding to important research needs of operating nuclear power plants in the U. S. The NEPO program implementation process has been well received by the nuclear utility industry and is recognized as an important element to its success.

Funding for NEPO was $5 million in both FY 2000 and FY 2001. In both FY 2000 and FY 2001, EPRI provided well in excess of the matching cost-share required by Congress. In FY 2000 EPRI cost-share was nearly $7 million and in FY 2001 EPRI cost-share exceeded $6 million. In both FY 2000 and 2001, DOE and EPRI staff presented about $18 million to $20 million in total annual funding requirements to the Coordinating Committee, from which they recommended selection of about $11-13 million in total annual work (DOE funding at $5 million and EPRI funding at $6-8 million). PCAST had recommended a level of $10M/year in government funding for this program. Because many of the projects require multi-year funding and since program funding remained level in FY 2001, initiation of new projects to address pressing issues was limited.

Some specific FY 2001 activities are listed below:

- A highlights document was prepared and issued in June 2001. This document was suggested by the Operating Nuclear Plants Research and Development Subcommittee of NERAC and supplements the *Joint Strategic Plan*. The purpose of the highlights document is to define major issues facing nuclear power plants and to explain the NEPO program goals.

- Routine program review meetings are being held between DOE and EPRI to ensure effective communication on program matters.

- For FY 2002, emphasis on open competition will continue and an increased emphasis will be placed on inclusion of minority educational institutions and businesses.

- Volume 2 of the *Joint Strategic Plan* will be revised on a yearly basis to identify high priority projects. Volume 1 will be updated on an as needed basis as the focus of required R&D shifts.

ATTACHMENT A
STATUS SUMMARY OF NEPO PROJECTS INITIATED IN FY 2000

3-1 Steam Generator (SG) Non-Destructive Examination (NDE) Test Mockup Facility and Tube Degradation Database

Task: Develop a library of well characterized, laboratory generated axial, circumferential, inner and outer diameter cracks for use in assessing advanced NDE methods being developed by DOE and EPRI.

Results to date:

- A glove box facility for NDE of tubes removed from service has been built.
- Inspection of six steam generator tube sections obtained from the McGuire retired steam Generators acquired through an USNRC program has been completed.
- A team of experts analyzed X-Probe data acquired from the steam generator mock-up developed in an USNRC program.
- Iconel 600 tubing test samples containing stress corrosion cracks have been prepared.

3-2 Advanced Eddy-Current Inspection System for Detection and Characterization of Defects in Steam Generator Tubes

Task: Develop an advanced eddy-current inspection technique and data analysis methodology for more reliable detection and accurate sizing of defects in steam generator tubes.

Results to date:

- Bobbin and Motor-Driven Rotating Pancake Coil (MRPC) data has been acquired from a test section containing three axial cracks of varying depths. Data has been acquired with and without interfering artifacts, such as tube supports and deposits.
- An effort was initiated on the development of automated data analysis algorithms to perform the function of anomaly detection and classification.
- Work on developing software to automatically analyze eddy current data from array probes has begun.

3-3 Overcoming Solubility Limitations to Zinc Addition in Pressurized Water Reactors (PWRs)

Task: Develop the solution thermodynamics of the Zn/ZnO system at high temperature in order to allow PWRs to safely inject as close as possible to the maximum Zinc concentration without ZnO precipitation on the core. Zinc addition to a PWR primary system reduces crack initiation frequency in Inconel Alloy 600 and potentially reactor head penetration materials/welds, but excessive Zinc can have adverse effects on nuclear fuel.

Results to date:

- Task is complete. Final report was issued in December 2001, *Overcoming Solubility Limitations to Zinc Addition in Pressurized Water Reactors, ERPI 1003156*.
- Experimental findings indicate that Zinc solubility is at least 100 ppb and therefore earlier estimates of 40 ppb based on extrapolating data from temperatures up to 200 degrees Celsius were overly conservative. Thus operating PWRs can increase zinc concentrations to levels, which have been shown to further decrease the risk of primary water stress corrosion cracking in laboratory testing.

3-7 Develop Empirical Data to Characterize Aging Degradation of Polymers Used in Electrical Cable

Tasks: Compare natural aging to model predictions based on accelerated aging; obtain naturally-aged samples; develop and confirm aging models; investigate bonded jacket cable failure mechanisms; evaluate coaxial connector backshell moisture intrusion and moisture dams.

Results to date:

- Several cable aging methods have been developed which are expected to have a significant impact to resolution of cable aging issues.
- First proof-of-principle experiments using the newly conceived wear-out approach show that it offers unique capabilities for predicting the remaining lifetimes of nuclear power plant cable materials.
- Bonded jacket insulation failure mechanism evaluation is proceeding well. Test specimens have been received from utilities and prepared for testing. Test plan has been developed. Oven aging of specimens was started on March 9, 2000. Aging occurred slower than expected and continued into November 2001. The project is expected to be completed by the end of May 2002.
- Coaxial moisture intrusion study is also proceeding well. Cable and connector components have been assembled. The LOCA test has been completed and evaluation of the specimens and data are under way.

3-8 Develop Condition Monitoring (CM) Techniques for Electric Cable

Tasks: Activities under this project include the development of a basis with material-specific correlation between non-destructive examination (NDE) data and destructive examination for localized (sample) inspections. Other activities include development of electrical NDE techniques capable of detecting incipient defects along an entire cable run and NDE techniques suitable for implementation at nuclear power plants. In addition, the project will develop distributed fiber optic temperature/radiation sensing methodology.

Results to date:

- Early results show that two new condition monitoring (CM) techniques based on modulus profiling and nuclear magnetic resonance measurements may be among the best CM techniques available for determining cable condition in existing nuclear power plants.
- Cable aging assessment training aids are being developed – cables have been received from utilities. Aging of the specimens is nearly complete.
- A Beta version of the database software has been issued to DOE.
- Contract awards have been made by EPRI to subcontractor research organizations and research has begun on low-voltage integrated cable aging management and for assessing the state of the industry and condition monitoring techniques for medium voltage cables.

3-13 Mechanical Behavior of Irradiated Structural Stainless Steels

Tasks: The project will determine the mechanical behavior of irradiated structural stainless steels under conditions of interest to Light Water Reactors (LWR) and tools to predict component life. The project will also assess the results of NDE examinations and guide the timing of corrective actions. In addition, the project will determine the effect of irradiation history on the irradiation assisted stress corrosion behavior of multiple alloys of austenitic stainless steel and multiple heats of selected materials in Pressurized Water Reactor (PWR) water.

Results to date:

- In-cell constant extension-rate testing (CERT) system has been developed at ANL. This system is capable of simultaneous testing of two specimens in separate loading trains at different or identical displacement rates (10^{-2} to 10^{-8} inch/sec) and different or identical temperatures (up to 800 degrees Celsius). The system can be used for testing of various specimen designs, including tensile, fracture mechanics, and point-bend specimens.
- Mechanical testing performed showed saturation of tensile characteristics (yield stress, ultimate tensile strength, uniform elongation and total elongation) achieved at 5 to 15 dpa with saturation levels higher for the 316CW material than for 304SA material. All four (French and US) 316CW materials showed homogeneity of the mechanical characteristics after irradiation regardless of their initial characteristics and no grain size effect was noticed. Four 304L SA materials also showed homogeneous mechanical characteristics after irradiation.

3-24 Fatigue Management

Tasks: Provide cost-effective methods of evaluating the cyclic life of nuclear components, including the effects of reactor coolant environment. The methods will be based on the safety margins of the American Society of Mechanical Engineer (ASME) code,. The project will also provide utilities with appropriate tools to manage fatigue effects.

Results to date:

- Issued an Interim Thermal Fatigue Management Guideline to assist utility operators in taking a pro-active approach in preventing unplanned leakage from piping attached to reactor coolant systems.

- Developed an Interim model for a thermal fatigue screening tool.
- Issued draft Guidelines for Addressing Fatigue Environmental Effects for a typical License Renewal Application. This document provides a method for considering reactor coolant environmental effects.

3-27 Assessment of Aging Effects on Components and Structures from Nuclear Power Plants

Tasks: Obtain materials and components that have been in service in operating reactors to be used for comparison with laboratory aged materials to validate models for aging effects and non-destructive examination methods.

Results to date:

- The Big Rock Point Condition Assessment Project, which identified reactor and other plant components which would be acceptable candidates for future aging tests, is complete.
- A survey document has been prepared and disseminated to utility and other industry materials aging experts to identify key components which should be sampled for aging testing/model validation.
- Materials and specific sections of reactor vessel internals of decommissioned San Onofre Nuclear Generation Unit 1 (SONGS 1) have been identified for harvesting. Samples from baffle plate, former plate, and core barrel are being harvested.

3-30 Irradiation Induced Swelling and Stress Relaxation of PWR Reactor Core Internal Components

Tasks: Characterize irradiation-induced void swelling and stress relaxation related to degradation that could occur in operating reactors, and calibrate and extend the liquid metal reactor-based swelling model for PWR applications.

Results to date:

- A state-of-the-art review of void swelling and irradiation enhanced stress relaxation was performed. The review revealed small amounts of void swelling (0.1-0.5 percent) in baffle bolts removed from operating PWRs.
- To support the development of a method for in situ measurement of void swelling, tests were conducted using eddy current, Barkhausen noise, electro-potential and three ultrasonic (conventional, guided wave, and back-scattering) nondestructive techniques. The materials tested were sets of surrogate material with electrical resistivity and Young's modulus altered by cold work or by use of powder metallurgy to determine the capability of each technique to measure 0.1 to 0.5% of void swelling. The eddy current, ultrasonic, and electro-potential methods have the most potential for field applications associated with the evaluation of void swelling and irradiation enhanced stress relaxation. These techniques will be used to evaluate void swelling attributes on irradiated materials, which represents a new application for these evaluation methods.

5-10 Qualification of a Smart Transmitter for Nuclear Safety Applications

Task: Qualify selected smart transmitters, performing the qualification testing and evaluation activities that can be done on a generic basis. This will save utilities and equipment suppliers from individually repeating the tasks for each application, and enhance regulatory acceptance.

Results to date:

- Task is complete.
- Documentation of the tests and evaluations that were performed is complete and a lessons learned report has been published.
- To demonstrate the qualification methodology developed by EPRI and approved by NRC for commercial-grade digital equipment, a smart transmitter from Rosemount was selected for evaluation and qualification. As a result, the Rosemount 3051C smart transmitter was successfully qualified and is now available as a 1E device from Rosemount for utility use, *Generic Qualification of the Rosemount 3051 N Pressure Transmitter, EPRI 1001468*. The manufacturer indicates that the new sensors should be calibrated every 10 years. This represents a significant reduction in calibration frequency over that of existing analog equipment and is expected to allow utilities to justify extending calibration frequencies for this type of transmitter.

5-12 Revision of Guideline on Licensing Digital Upgrades Based on Revised 10CFR50.59 Rule

Task: Develop an industry consensus approach for implementing digital upgrades to safety systems under the new 10 CFR50.59 regulation and gain NRC approval of the approach. This task will revise and update EPRI TR-102348, "Guideline on Licensing Digital Upgrades," which was developed to stabilize the regulatory environment in 1993.

Results to date:

- Electric Power Research Institute (EPRI) and Nuclear Energy Institute (NEI) have established a joint utility Task Force to guide this effort.
- A draft of the revised guideline was developed and distributed for broad industry review and NRC review and comment.
- Publication of the final report is scheduled for the end of March 2002, with subsequent submission to NRC for formal review.

5-17 Cost-Benefit Study for Optimum Fuel Burnup and Cycle Length

Task: Conduct an industry-wide cost benefit analysis to determine optimum cycle lengths and fuel discharge burnup levels for nuclear power plants (Boiling Water Reactors (BWR) and Pressurized Water Reactors (PWR)) to achieve maximum environmental, safety and economic benefits. Specifically, identify the optimum fuel batch average discharge burnups achievable under the current limitation of 5% on enrichment for different cycle lengths; determine whether reaching the optimum values will require exceeding the currently licensed maximum burnup

limit of 62 GWd/MTU. Evaluate the benefits achievable by exceeding the 5% enrichment limit and identify the obstacles that would have to be overcome to reach such an objective.

Results to date:

- Phase I of this project has been completed. This phase identified the optimum burnups and cycle lengths achievable within the 5% enrichment limit. Results indicate that for both BWRs and PWRs fuel costs are reduced by increasing discharge burnup. For BWRs the benefits are greatest when operating under 24-month refueling cycles. PWRs operating on 24-month cycles cannot increase burnup significantly without having to exceed the enrichment limit. For PWRs the 18-month cycle is shown to yield the greatest potential benefits. The report, *Optimum Cycle Length and Discharge Burnup for Nuclear Fuel - A Comprehensive Study for BWRs and PWRs, Phase 1: Results Achievable Within the 5% Enrichment Limit, ERPI 1003133,* was published in December, 2001.

5-19 Impact of Nickel Oxide Solubility on Axial Offset Anomaly (AOA) in PWRs

Task: Investigate the role of fuel deposit solubility as a means of mitigating problems with recently observed anomalous core flux depressions due to increased primary coolant corrosion product deposition (primarily Nickel Oxide) onto fuel cores with increased design thermal duties. This deposition creates a phenomenon called Axial Offset Anomaly which can require a power reduction to maintain regulatory shutdown margin. This project will develop the database on nickel solubility from NiO for temperatures ranging from shutdown/startup conditions (25-90C) to fuel pin operating temperatures (up to 350 C).

Results to date:

- Task 1 on obtaining data during reactor coolant system shutdown evaluations (temperatures below 100 degrees Celsius) is complete and the final report was issued in February 2001.
- Task 2, which will obtain data during power operation (temperatures up to 350 degrees Celsius), was initiated in September 2001.

5-21 Human Performance Indicators and Corrective Action Plans

Task: The project was established to develop guidance on the selection and use of leading indicators to support early identification of human performance problems in maintenance, repair, and operations. The project also extended the range of the use of the analytical indicator approach and software capabilities to related issues (e.g., employee concerns). In addition, the project focused on the development of a more comprehensive database of corrective actions taken in response to human errors at other organizations and industries.

Results to date:

- Task is complete.
- *Guidelines for Trial Use of Leading Indicators of Human Performance, EPRI 1000647,* were published in September 2000.
- "Proactive Assessment of Organizational and Workplace Factors" (PAOWF) is in use at two nuclear power plants and is being installed at several more.

ATTACHMENT B
STATUS SUMMARY OF NEW NEPO PROJECTS INITIATED IN FY 2001

3-29 Motor Rewind Insulation Systems Development and Qualification for Harsh Environments

Task: Produce random-wound continuous duty motor test specimens for use in environmental qualification testing for inside and outside containment conditions.

Results to date:

- The preliminary fabrication procedure for rewinding AC random-wound continuous duty motors has been completed and issued for use in building qualification test specimens. The fabrication procedure includes fabrication and processing procedure steps based on experience in constructing the previous random-wound, intermittent duty (motor operated valve motor) test specimens. The procedure is also based on the performance of various insulating materials and fabrication methods in EPRI's Motor Operated Valve insulation system qualification test program.
- Specifications have been developed for stator windings in five motors to be fabricated for qualification testing. The test specimens will employ multiple winding material configurations, including several resin types and magnet wire constructions, to identify the materials that are best suited for harsh environment conditions. The insulation systems developed in this project employ unique construction methods not previously used in any nuclear-grade or severe-duty industrial motors. Winding, resin processing, and assembly of the first motor is currently underway.

5-106 Low Power and Shutdown Probabilistic Risk Assessment (PRA) Benchmarking

Tasks: The purpose of this project is to benchmark existing quantitative low power and shutdown (LPSD) PRA results to determine the correlation between configuration controls on Plant Operating States (POSs) and the risk levels produced by them. It is expected that this benchmarking will provide bounding levels of risk associated with each POS if defined configuration controls are applied. These bounding values may then be used to represent the risk level of these POSs, thus precluding the need for further quantitative PRA assessment. The project will define a set of quantitative LPSD PRA results to provide suitable benchmark comparisons. A survey of existing quantitative LPSD PRAs and the collection of data for the correlations in order to understand the state-of-the-industry in LPSD PRA will be performed. Correlations between configuration controls and the associated risk level calculated using the quantitative LPSD PRAs, and sets of configuration controls and quantitative risk levels that impact quantitative risk will also be determined.

Results to date:

- Quantitative LPSD PRA results sets have been defined, and a draft report has been prepared.
- A draft Survey has been prepared for distribution to utilities.

5-107 Develop Methods to Incorporate Organizational Factors into Risk

Task: To increase nuclear plant safety and improve operation by assessing the impact of organizational factors on risk. Primary goal is to develop tools to quantify the risk in a PRA by:

- Producing an initial assessment of recent international work on organizational factors and how they can be quantified in a PRA. The project will also assess whether the techniques developed in the MERMOS code can be extended to include pre-initiator as well as post-accident situations, and whether a bottom-up approach will be better suited to the quantification than the traditional top down approach.
- Producing Guideline for incorporating organizational factors into a PRA. The existing SHARP technique will form the basis for the Guideline. The Guideline will show how to incorporate organizational factors into an HRA framework.

Results to date:

- Electric Power Research Institute (EPRI) and Electricity de France (EdF) have established a joint project team to investigate the suitability of existing codes to provide quantified evaluation of organizational factors for PRAs. EdF is preparing a report on "Assessment of International Work on Organizational Factors."
- A final draft of the survey report entitled "Quantification of Organizational Factors" has been completed.
- An RFP (competitive selection) for the project workscope was issued and a contractor selected (Scientech)
- Preliminary work on a Workshop on Organizational Factors has been started (Scheduled for February 2002). The Workshop will result in the development of a consensus Guideline

5-108 Organizational Factors Leadership Process Development

Task: Develop a framework to effectively and efficiently identify and control organizational factors that significantly influence human performance both positively and negatively. Knowledge management software will also be evaluated for its capability in reducing the effort required to self-assess and respond to organizational factors affecting human performance.

Results to date:

- Existing industry practices have been compared with established research theories on organizational factors. The results of the comparison will more readily allow the integration of these theories into industry procedures and practices supporting performance improvement.
- Initial report, "*An Integrated Framework for Performance Improvement: Managing Organizational Factors,*" EPRI Report 1003034, was published in December 2001.

- A research plan has been developed to validate the proposed "integrated framework for performance improvement" and to develop objective methods and specific process tools that will be needed if a tighter integration across the industry is to be achieved.

5-110 Technical Basis, Processes, and Guidance for Hybrid Control Rooms in Nuclear Power Plants

Tasks: The purpose of the project is to develop the technical bases, processes, and guidance for the definition, design, implementation, regulatory interaction, training, operation, and maintenance of hybrid control rooms. The scope of the project also included human-system interfaces, including careful consideration of human cognitive requirements. The technical bases and guidance will also address advanced technologies, such as automation, computerized operator support systems, and more sophisticated display approaches than currently used. In addition to meeting NRC safety requirements and the plant's operational requirements, the guidance will support improved cost-effective plant and human performance and will reduce the likelihood of human errors.

Results to date:

- A heavily annotated outline of the overall guidance document for hybrid control rooms has been developed and is being used as the basis for identifying technical basis and guidance activities. This outline is a living document as the industry working group defines additional needs.
- The draft of the processes for defining operational strategies (including operations under abnormal conditions), the plant-specific hybrid control room functionality, and interface configuration at the end of the modernization program has been written. This includes the technical bases and considerations needed to use these processes to define a plant-specific operational strategy, desired control room configuration at the end of the modernization program, and the migration plan to accomplish the transition. The draft will be reviewed by members of the industry hybrid control room working group.
- The draft of the guidance and technical basis for security and configuration management for displays and information has been written and will be reviewed by members of the industry hybrid control room working group.
- The draft of the guidance and technical basis on human factors engineering tools and methods has been written and will be reviewed by members of the industry hybrid control room working group.
- A preliminary identification of the skill sets needed by the plant owner/operator for successful implementation, operation, and maintenance of hybrid control rooms has been documented.

5-113 On-line Monitoring of Non-redundant Sensors for Signal Validation and Calibration Reduction

Task: Support efforts in plant implementation of Argonne National Laboratory (ANL)-developed MSET software for signal validation and instrument calibration reduction in the verification and validation (V&V) of MSET software; uncertainty analysis and system modeling.

Results to date:

- DOE-EPRI completed negotiations with ANL for scope of work to be performed in 2001.
- Implementation of MSET for modeling key non-redundant sensors is underway at 3 nuclear plant sites.
- Preliminary modeling for MSET has been completed at these plant sites.
- The V&V Plan is under development.

5-115 Electromagnetic Interference (EMI) Testing Requirement for Nuclear Power Plants

Task: Acquire and analyze plant emissions data to validate revised EMI testing limits for plant safety-related digital equipment.

Results to date:

- EPRI awarded a contract with Wyle Labs to collect plant emissions data at four nuclear plant sites.

5-117 R&D Needs to Address Potential Nuclear Plant Vulnerabilities arising from Transmission Grid Voltage Inadequacies

Task: To increase nuclear plant safety and protect the transmission grid from further instabilities caused when nuclear unit might be forced off line due to grid voltage problems, by:

- Developing a risk monitor tool to assist transmission system managers in making decisions involving low reserve margins, shortage of transmission facilities and technical problems in transmitting power over long lines.
- Providing 'return to service' priorities to restore system margin or determining which assets to protect to prevent erosion of system margin.

The goal is that the nuclear plants can use local grid reliability information to evaluate the safety of the plant, and, in return, the grid operators can obtain the probability that the nuclear plant will trip off line to evaluate the security of the grid. A pilot application and demonstration will be performed at a nuclear unit in a region of the country experiencing grid congestion.

Results to date:

- Electric Power Research Institute (EPRI) and Oak Ridge National Laboratory (ORNL) have established a joint project team to perform this work
- A final draft of the Technical Specifications for the Grid Risk Integration Tool (GRIT) has been completed.
- The work on nuclear plant-side trip monitor (a software module for the Risk and Reliability Workstation) has started, and a report 'TRIP MONITIOR for the prevention of Loss of Off-Site Power / Lessons Learned and Experience" has been completed.
- Work on the probability of various losses of off-site power events has been started.